

---

# Interim Guidance for Investigating Potential 1,2,3-Trichloropropane Sources in San Gabriel Valley Area 3

QUESTION: Can we use consistent units to report measured 1,2,3-TCP concentrations in water? We go back and forth between using ng/L and ug/L.

Prepared for  
**United States Environmental Protection Agency,  
Region 9**

Prepared by  
**CH2MHILL**  
3 Hutton Centre Drive  
Suite 200  
Santa Ana, CA 92707

July 2005

# Contents

---

Section	Page
<b>Interim Guidance for Investigating Potential 1,2,3-Trichloropropane Sources in San Gabriel Valley Area 3</b> .....	<b>1</b>
1. Purpose and Scope .....	1
2. Identification of Potential Sources .....	1
3. Investigation and Sampling Strategies .....	5
4. Sampling Methods .....	7
4.1 Groundwater .....	8
4.2 Soil .....	9
4.3 Soil Gas .....	9
5. Analytical Methods .....	10
5.1 Groundwater .....	10
5.2 Soil .....	12
5.3 Soil Gas .....	13
6. Remediation and Treatment .....	15
6.1 Remediation .....	15
6.2 Treatment .....	17
7. References .....	18

## Appendixes

- A Chemical Properties/Environmental Fate and Transport
- B Uses and Manufacturers
- C Regulatory Levels
- D Occurrences of 1,2,3-TCP Environmental Contamination in the U.S.
- E Health Risk Information

---

## Tables

2-1	Uses of 1,2,3-TCP, Products, and Types of Businesses Using Products.....	2
3-1	Summary of Investigation Tasks and Descriptions.....	5
3-2	Comparison of Contaminants to Potential Businesses/Operations.....	6
4-1	1,2,3-TCP Sampling Methods.....	7
5-1	DHS-Approved Analytical Methods for 1,2,3-TCP in Water.....	10
5-2	Other Analytical Methods for 1,2,3-TCP in Water.....	12
5-3	Analytical Methods for 1,2,3-TCP in Soil.....	13
5-4	Analytical Methods for 1,2,3-TCP in Soil Gas.....	14
6-1	Remediation Approaches for 1,2,3-TCP Contamination.....	15
6-2	Ex-Situ Groundwater Treatment Technology Screening for Removal of 1,2,3-TCP.....	17
A-1	Chemical Names and Identifiers.....	A-1
A-2	Chemical Properties of 1,2,3-TCP.....	A-2
B-1	1,2,3-TCP Manufacturing Information.....	B-2
D-2	Reported RCRA Releases in the United States During 2002.....	D-4

## Figures

2-1	1,2,3-Trichloropropane Contamination in SGV Area 3.....	2
-----	---	---

# Interim Guidance for Investigating Potential 1,2,3-Trichloropropane Sources in San Gabriel Valley Area 3

---

## 1. Purpose and Scope

This document has been prepared to provide guidance to the United States Environmental Protection Agency (USEPA) Region 9 and the Los Angeles Regional Water Quality Control Board (LARWQCB) in locating potentially responsible parties (PRPs) who may have used the chlorinated volatile organic compound (VOC) 1,2,3-trichloropropane (1,2,3-TCP). An additional intended use of this document is to guide LARWQCB oversight of investigations at PRP facilities in San Gabriel Valley (SGV) Area 3 of the San Gabriel Basin Superfund Site in Los Angeles County, California, to assess potential releases of 1,2,3-TCP.

The body of this document provides a summary of background information on the identification of potential sources, investigation and sampling strategies, sampling methods, analytical methods, and remediation of 1,2,3-TCP contamination. Information on chemical properties, environmental fate and transport, uses and manufacturers, regulatory levels, documented occurrences of 1,2,3-TCP environmental contamination in the United States, and health risk information is provided in a series of appendices. This document ~~is~~ intended to be used as interim guidance for investigating potential 1,2,3-TCP sources in SGV Area 3 and may be updated in the future as deemed necessary.

1,2,3-TCP is a synthetic (not naturally occurring) chemical that is a clear, colorless, dense, moderately volatile, moderately flammable liquid, described as having a sweet but strong acrid odor similar to chloroform. 1,2,3-TCP was previously used as a solvent, as a soil fumigant, and as a branching agent for polysulfide polymers. Alternate chemical names, chemical properties, and environmental fate and transport characteristics are provided in Appendix A. The California Department of Health Services (DHS) notification level (NL) for 1,2,3-TCP in drinking water is 0.005 µg/L.

## 2. Identification of Potential Sources

1,2,3-TCP occurs in groundwater in the central portion of SGV Area 3 at concentrations of up to 413 ng/L (0.413 µg/L)[Figure 2-1]. The depth to groundwater in this portion of Area 3 ranges from approximately 275 to 300 feet below ground surface (bgs) as of January 2004. The subsurface alluvial sediments consist predominantly of sand and gravel, with minor amounts of silt and clay.

The source(s) of 1,2,3-TCP contamination in SGV Area 3 have not been determined to date. (This is a very awkward sentence) Because of the significant depth to water in the central portion of the operable unit (OU), contaminant travel times between the ground surface and groundwater table, depending on the volume of a release (i.e., a large amount over a short

Formatted: Font color: Orange

duration or smaller quantities over a long duration), are expected to be on the order of tens of years (can we say decades?). Therefore, sources (e.g., facilities) of potential concern include those that either have operated for many years (i.e. decades) or have used large quantities of chemicals, or both. The ~~previous existence of a "dry well" for~~ disposal of relatively small quantities of liquid waste containing 1,2,3-TCP ~~through a previously existing "dry well"~~ is another potential mechanism to explain the 1,2,3-TCP groundwater contamination in Area 3 (see Appendix D, MacKenzie Chemical Works site), although none have been identified in SGV Area 3.

Formatted: Font color: Orange

Uses and manufacturers of 1,2,3-TCP are described in Appendix B. Based on this information, the types of businesses (e.g., facilities) that are considered to be potential sources of 1,2,3-TCP releases are summarized in Table 2-1. ~~(I'm not sure it makes sense to say "businesses that are ... potential sources..")~~

Formatted: Font color: Orange

Formatted: Font color: Orange

**TABLE 2-1.**  
Uses of 1,2,3-TCP, Products, and Types of Businesses Using Products

Uses of 1,2,3-TCP	Products	Types of Businesses	Comments and Example Site or Source <sup>a</sup>
<b>Former (Historic) Uses</b>			
Paint and varnish solvent	Paint and varnish	Paint manufacturers	The cited uses were referenced in Johnson (1968), but are not known today. No information is currently available to indicate that these uses continue.
	Paint and varnish stripper	Commercial painting facilities	
	Furniture finish remove	Solvent manufacturing or recycling facilities	
		Paint stripping facilities	
Degreasing agent	Degreasing agent	Metals plating shops	Former MCAS Tustin, CA. Use of 1,2,3-TCP is estimated to have occurred in the 1950s. <sup>b</sup>
		Painting facilities	
		Electronics manufacturers	
Soil fumigants of which 1,2,3-TCP is a minor component	D-D	Agricultural applications	Central Valley, CA. Used from 1946 to the present.
	Telone II	Soil fumigants were used on citrus fruits, pineapple, soy beans, cotton, tomatoes, and potatoes.	

**TABLE 2-1.**  
Uses of 1,2,3-TCP, Products, and Types of Businesses Using Products

Uses of 1,2,3-TCP	Products	Types of Businesses	Comments and Example Site or Source <sup>a</sup>
"Branching" agent for polysulfide polymers	Aircraft tank sealants	Aircraft manufacturers Aircraft fuel tank manufacturers Aircraft maintenance facilities	San Fernando Valley Superfund Site (Area 1 – North Hollywood and Burbank) Polysulfides have been in used for aircraft tank sealing since the 1950s.
	Binder for rocket fuel	Rocket motor manufacturers Rocket motor test facilities	Used for rocket fuel binder from 1946 to 1958.
	Construction sealants	Commercial construction	Used as construction sealants since the 1950s.
<b>Current Uses</b>			
Chemical intermediate for synthesis of other products	Polysulfone liquid polymers	Aerospace, automotive, consumer goods, electrical, electronic, health care and industrial equipment	
	Polysulfides	Compressor and pump valve components	
Chemical intermediate for synthesis of other products	Hexafluoropropylene (key building block to produce Teflon fluoropolymers)	Agrochemical, electronics, dyes/pigments, pharmaceutical, and specialty polymer facilities	Ciba-Geigy, NJ
	Polysulfides (catalyst sulfidation agents, formulation of extreme pressure lubricant additives)	Lubrication product manufacturers	
Byproduct of the manufacture of epichlorohydrin	Over 80 percent of the 1,2,3-TCP manufactured in the U.S. is a byproduct of the manufacture of epichlorohydrin and is incinerated onsite	Petrochemical/industrial chemical complexes	No epichlorohydrin manufacturing is known to have occurred in the San Gabriel Valley.
"Branching" agent for polysulfide polymers	Polysulfide polymer sealants	Window manufacturers Boat manufacturers	Polysulfide polymer sealants are still used for glass sealants and construction adhesives.
	Sealants for insulating glass windows	Adhesive manufacturers	
	Construction adhesive		
	Boat hull sealants		

**TABLE 2-1.**  
Uses of 1,2,3-TCP, Products, and Types of Businesses Using Products

Uses of 1,2,3-TCP	Products	Types of Businesses	Comments and Example Site or Source <sup>a</sup>
"Branching" agent for polysulfide polymers	Aircraft tank sealants	Aircraft manufacturers Aircraft fuel tank manufacturers Aircraft maintenance facilities	San Fernando Valley Superfund Site (Area 1 - North Hollywood and Burbank), California. Polysulfide polymers have been used as aircraft tank sealants from the 1950s to the present.
Soil fumigants of which 1,2,3-TCP is a minor component	Telone II	Agricultural applications Soil fumigants were used on citrus fruits, pineapple, soy beans, cotton, tomatoes, and potatoes.	Central Valley, CA. Telone II (introduced in 1956) is still in use for vegetables, field crops, fruit and nut trees, grapes, nursery crops and cotton.

Notes:

<sup>a</sup> See Appendix D. Only limited information is available for the periods of use of some of these chemical products. Therefore, the cited periods of use may not preclude use during other time periods.

<sup>b</sup> Associated with a former vehicle maintenance building.

Of the types of businesses that have historically used 1,2,3-TCP (Table 2-1), the most likely ~~types of businesses~~ to have operated in SGV Area 3 in the past are paint manufacturers, commercial painting facilities, paint stripping facilities, metal plating shops, electronics manufacturers, solvent manufacturer or recyclers, aircraft fuel tank manufacturers, rocket motor test facilities, and aerospace, automotive, compressor, and lubrication manufacturers. It should be noted that further refinement of Table 2-1 to a short list of businesses most likely to have historically used 1,2,3-TCP will require significantly more effort than ~~that allotted forexpended in~~ preparation of this interim guidance document.

It is possible that prior agricultural activities could have ~~contributed to potentially been responsible for some~~ 1,2,3-TCP groundwater contamination. However, the relatively limited extent of contamination in SGV Area 3 is more consistent with a ~~release originating from point source for the contamination~~. Unless a release occurred at a fumigant storage or distribution facility, agricultural activities would be expected to result in more widespread 1,2,3-TCP contamination ~~at relatively low concentrations, rather than the more isolated 1,2,3-TCP at concentrations in groundwater of over 400 ng/L present in SGV Area 3 (This sentence implies that 400 ng/L is not a relatively low concentration (or is a relatively higher concentration), which I'm not sure is accurate. Although it significantly exceeds the NL, I still would consider it low. Can we clarify?)~~. Also, as presented in Table 3-2, other VOCs commonly found in soil fumigants at present have not been detected in groundwater in SGV Area 3.

Formatted: Font color: Orange

### 3. Investigation and Sampling Strategies

A summary of site investigation tasks and descriptions is provided in Table 3-1. Because of the chemical properties of 1,2,3-TCP (volatility, solubility, mobility), a combination of environmental media will need to be sampled to identify sources of 1,2,3-TCP groundwater contamination: soil, groundwater, and potentially soil gas (only if an actual true near-surface source area has been identified). Initiating site investigations through soil gas sampling may not produce data of sufficient quantity and quality to identify an area of a 1,2,3-TCP release, based on past experience in the San Fernando Valley Superfund Site (Area 1 - North Hollywood and Burbank), California (Tetra Tech, 2003). (I think we're specifically concerned with false negative results, rather than with failing to generate data of sufficient quantity and quality. Please clarify.)

TABLE 3-1.  
Summary of Investigation Tasks and Descriptions

Investigation Task	Description
Determine Study Area	<p>Focus study areas on areas of regional 1,2,3-TCP groundwater contamination, and on areas that are up gradient of existing regional contamination.</p> <p>Migration of 1,2,3-TCP contamination may not initially be governed by the regional groundwater flow direction, but may at first follow any preferential pathways in subsurface strata in the vadose zone. In some cases, the preferential flow direction of soil vapor in the vadose zone may be significantly different from the preferential flow direction of groundwater in the saturated zone. <u>(Is this really an uncommon circumstance? Does soil vapor generally flow in the same direction as GW?)</u></p>
Perform PRP Searches and File Reviews	<p>Focus PRP searches and file reviews on the types of operations/businesses listed in Table 2-1.</p> <p>The business/operation may potentially be evaluated by looking for contaminants that occur with 1,2,3-TCP in soil and groundwater, as summarized in Table 3-2.</p> <p>Review regulatory files at the Regional Water Quality Control Board (RWQCB), the California EPA - Department of Toxic Substances Control (DTSC), and the City Fire Department Hazardous Materials Management Unit for any evidence of 1,2,3-TCP use or release. <u>Specific documents to be reviewed relevant documents, including ed include</u> material safety data sheets (MSDS), hazardous materials business plans, and chemical inventory information.</p> <p>Review site investigation reports (including Phase I environmental assessments, preliminary site investigations, subsurface investigations, hydrogeologic assessments, groundwater monitoring reports, soils investigations, underground storage tank (UST) and above-ground storage tank (AST) leak detection, investigation and closure reports, excavation reports, soil gas survey investigations, and soil and groundwater samples) that included 1,2,3-TCP as an analyte.</p>
Review of Groundwater Monitoring Data	<p><u>Determine whether groundwater samples from wells may need to be resampled-analyzed</u> for 1,2,3-TCP (see Appendix C for additional detail on this topic). <u>because 1,2,3-TCP analytical methods was generally not provided inadequate sensitivity to meet analyzed with</u> low-level reporting limits until approximately 1999, when a DHS Action Level (now referred to as the notification level [NL]) was established. The detection limit for 1,2,3-TCP in groundwater prior to 1999 may <u>have been</u> as high as 10 µg/L, which is well above the current DHS NL of 0.005 µg/L. <u>1,2,3-TCP may have been reporteddetected</u> as a tentatively identified compound (TIC) in historic monitoring data at concentrations exceeding approximately 90 µg/L</p>

**TABLE 3-1.**  
Summary of Investigation Tasks and Descriptions

Investigation Task	Description
Soil Gas Sampling	<del>The success of s</del> Soil gas surveys <del>are currently anticipated to may</del> be <del>limited of limited success as an approach</del> for investigating potential 1,2,3-TCP releases. Therefore, <del>base</del> soil gas surveys <del>should be based</del> on an evaluation of prior facility operations, <del>and should subsequently be focus</del> <del>ing</del> <del>ed in on</del> areas where 1,2,3-TCP releases are likely to have occurred. The need for <del>performing</del> focused soil gas surveys, <del>as opposed to comprehensive/general/ unfocused soil gas surveys</del> , is based on prior experience at the San Fernando Valley Superfund Site (Area 1 - North Hollywood and Burbank).
Subsurface Soil Sampling	<del>Collect and analyze s</del> Soil samples <del>should be collected and analyzed</del> every 5 to 10 feet over the entire depth of a boring, because the detection of 1,2,3-TCP may be limited to small stratigraphic lenses over short intervals, as observed in San Fernando Valley Superfund Site (Area 1 - North Hollywood and Burbank) (Tetra Tech, 2003). Alternatively, <del>selected</del> soil samples <del>may be for analysis</del> <del>sized</del> according to observed elevated head space readings, as measured with an organic vapor analyzer (OVA) or flame ionization detector (FID).  The traditional approach for collecting and analyzing subsurface soil samples by direct push methods, a California modified soil sampler, or equivalent is recommended.
Groundwater Sampling	Collect groundwater samples for 1,2,3-TCP analysis from existing monitoring and production wells, and install new monitoring wells at key locations to help further refine the interpreted extent of 1,2,3-TCP <del>contamination</del> in groundwater.

The occurrence of 1,2,3-TCP with other contaminants in soil or groundwater may in some cases assist in determining the source of 1,2,3-TCP in soil or groundwater, as summarized in Table 3-2.

**TABLE 3-2.**  
Comparison of Contaminants to Potential Businesses/Operations

Contaminants Detected in Groundwater	Potential Business/Operation (see Appendix B)
1,2,3-TCP only	Painting or paint stripping, aviation/fuel tank sealing, boat construction facilities, compressor and pump maintenance/manufacturing
1,2,3-TCP with trichloroethene (TCE), tetrachloroethene (PCE)	Metal or plastics plating facility, paint stripping facility, painting facility, aviation/fuel tank sealing, automotive manufacturing, mechanical maintenance shop
1,2,3-TCP and perchlorate	Aerospace/rocket motor production, testing, and disposal
1,2,3-TCP with 1,2-dichloropropane, 1,2,2-trichloropropane, and potentially ethylene dibromide [EDB] and 1,2-dibromo-3-chloropropane [DBCP].	Agricultural application (especially citrus) of soil fumigant; storage or distribution center of agricultural chemicals

The California Department of Pesticide Regulation advised that ~~in locations~~ where 1,2,3-TCP is a contaminant of concern, the groundwater should also be analyzed for 1,2-dichloropropane, which commonly occurs in much higher concentrations than 1,2,3-TCP, and 1,2,2-trichloropropane (1,2,2-TCP), which is a byproduct of the manufacture of 1,3-

dichloropropene (Howe et al, 1999). Ethylene dibromide (EDB) and 1,2-dibromo-3-chloropropane [DBCP] are other common soil fumigants that may be present in groundwater.

## 4. Sampling Methods

Recommendations for sampling methods for collection of soil, groundwater, and soil gas samples for 1,2,3-TCP analyses are provided in this section. All sampling methods are listed and briefly described in Table 4-1. Following this table, Sections 4.1, 4.2, and 4.3 provide additional details on ~~specific issues pertaining to sampling~~ of each medium. Analytical methods are provided in Section 5.

TABLE 4-1  
1,2,3-TCP Sampling Methods

Media	Sampling Method	Sample Container
<b>Groundwater</b>		
Groundwater – in situ samples	HydroPunch™ sampler, (collect groundwater sample with small diameter bailer inside HydroPunch assembly, decant to VOA vial)	40-ml VOA vial, HCl to pH <2, no headspace, cooled to 4°C.  Cool glass vial to 4°C immediately upon retrieval, submit to lab for analysis.
	BAT™ system groundwater sampler (evacuated 120-ml glass vial) is filled when septa is punctured in the subsurface  SimulProbe™ (able to collect simultaneous soil and groundwater samples)  <b>NOTE:</b> Use of in situ, depth-specific samples permits characterization of the vertical extent of 1,2,3-TCP contamination.	Immediately transfer liquid sample to 40-ml VOA vial, HCl to pH <2, no headspace, cool to 4°C.  <b>NOTE:</b> Given the depth to groundwater in SGV Area 3 (275 to 300 feet bgs), the <del>cost to collection of</del> in situ groundwater samples below the water table may be cost prohibitive. Depending on the depth of sample collection, these in situ methods may need to be used in combination with subsurface drilling methods.
Groundwater – production wells	Fill sample container directly from wellhead tap, taking care to minimize sample aeration.	40-ml VOA vial, HCl to pH <2, no headspace, cool to 4°C.
Groundwater - monitoring well	Dedicated pump (low-flow method preferred)	Directly fill 40-ml VOA vial, HCl to pH <2, no headspace, cool to 4°C.
	Diffusion bag sampler(s) (allow to equilibrate per instructions)  <b>NOTE:</b> With the aid of multiple samplers <del>(clarify that we mean multiple sample collection devices and not multiple persons collecting samples)</del> , a vertical concentration profile may be obtained.	Carefully decant sample(s) into 40-ml VOA vial(s), HCl to pH <2, no headspace, cool to 4°C.  <b>NOTE:</b> Vroblesh and Campbell (2001) report that when using polyethylene based passive diffusion samplers for VOCs, the concentrations of 1,2,3-TCP measured with the diffusion bag sampler was within 10 percent of the concentration in ambient water.
Multiple-port groundwater monitoring well	Use Westbay sampling equipment to collect groundwater sample	Fill 40-ml VOA vial directly from Westbay sample container, HCl to pH <2, no headspace, cool to 4°C

TABLE 4-1  
1,2,3-TCP Sampling Methods

Media	Sampling Method	Sample Container
<b>Soil</b>		
Soil - surface	Sample directly with Encore sampler	Encore sampler, cooled to 4°C.
	Sample collection in a glass jar may be acceptable if soil conditions (e.g., the presence of gravel) prevents the use of an Encore sampler. This will require approval on a case-by-case basis. If approved, collect the grab sample with stainless steel spade, packing soil tightly into jar.	4-ounce glass jar (no headspace), cooled to 4°C.
Soil – subsurface	Direct push sampler	Brass or stainless steel (SS) sample sleeve; seal end with Teflon tape, foil, and plastic end caps; cooled to 4°C.
	Piston sampler	
	California modified soil sampler	
	SimulProbe™ (able to collect simultaneous soil and groundwater or soil and soil gas samples)	
<b>Soil Gas</b>		
Soil Gas	Install temporary or permanent soil gas sampling probe, purge, and sample per LARWQCB/DTSC guidance (2003).	Syringes, glass bulbs wrapped in Aluminum foil, SUMMA™ canisters.

## 4.1 Groundwater

Groundwater samples may be collected from production wells, conventional groundwater monitoring wells, multiple port monitoring wells, and with diffusion bag samplers. In-situ (depth-specific) groundwater samples may be collected to characterize the vertical extent of 1,2,3-TCP groundwater contamination.

### Monitoring Wells

Sample collection from conventional and multiple port monitoring wells is the most common and direct method for detecting and monitoring 1,2,3-TCP in groundwater. A low-flow ~~method~~ sampling method is recommended to minimize 1,2,3-TCP losses due to volatilization from turbulence within the well and during filling of sample containers. Samples collected in this manner will yield laboratory analytical results that are ~~considered to be~~ more representative of actual in situ groundwater concentrations.

### Diffusion Bag Samplers

Vroblesh and Campbell (2001) reported that when using polyethylene based passive diffusion samplers for VOCs, concentrations of 1,2,3-TCP measured in samples collected with the diffusion bag sampler were within 10 percent of the concentrations in ambient water. This close agreement indicates that diffusion bag samplers are a viable alternative for collection of groundwater samples for analysis of 1,2,3-TCP. If a series of bags are suspended at different depths in a well, a vertical profile of 1,2,3-TCP concentrations may be

---

obtained, assuming that the well is not acting as a conduit for vertical groundwater flow (which would result in non-representative samples). This method is best suited for detailed profiling in wells with relatively short ~~(i.e., 50 feet or less)~~ monitoring well screen intervals ~~(i.e., 50 feet or less)~~. Procedures for use of diffusion bag samplers are provided in ITRC (2004).

### In Situ Groundwater Sampling

In situ (depth-specific) sampling during drilling of monitoring wells can be performed using a HydroPunch™, SimulProbe, or BAT™ sampler in order to assess the vertical extent of 1,2,3-TCP groundwater contamination. However, given the depth to groundwater in the central portion of SGV Area 3 (275 to 300 feet bgs), the ~~cost to use of~~ this approach as a screening technique ~~likely~~ would be ~~cost prohibitively expensive~~ and time consuming.

## 4.2 Soil

Soil samples for analysis should be collected in Encore samplers to reduce 1,2,3-TCP losses from volatilization. Direct push samples collected in stainless steel or brass sleeves should be sealed with Teflon tape, foil, and plastic end caps. For samples of loose soil with gravel or coarse, loose sand or gravel that cannot be sampled with an Encore sampler, pack the soil tightly into a 4-ounce glass jar and close the cap tightly. It should be noted that given the moderate volatility of 1,2,3-TCP, surface soil samples are unlikely to contain detectable concentrations of 1,2,3-TCP. Consequently, an alternative approach to characterizing concentrations of 1,2,3-TCP in soil, ~~for example during screening level investigation of a site~~, would be to use heated soil head space field analyses, ~~for example during screening-level investigation of a site~~. All samples should be placed on ice immediately and maintained at 4°C prior to analysis.

~~The selection of s~~Subsurface samples ~~can be selected~~ for submittal to a laboratory for 1,2,3-TCP analysis ~~can be targeted~~ based on headspace concentrations, visible staining, or odor. Concentrations of 1,2,3-TCP are expected to be higher in fine-grained materials (e.g., silt), than ~~in~~ coarse-grained materials (e.g., gravel), where ~~1,2,3-TCP#~~ would ~~volatilize be~~ more easily ~~volatilized~~ in the vadose zone or ~~dissolve be~~ more ~~readily~~ rapidly flushed away by ~~groundwater flow~~ in the saturated zone (i.e., below the groundwater table).

## 4.3 Soil Gas

Little information is available on the effectiveness of soil gas surveys in assessing sources and releases of 1,2,3-TCP and the extent of 1,2,3-TCP soil contamination. A soil gas survey was completed during 2003 at the Aeroquip Corporation in the San Fernando Valley Superfund Site (Area 1 - North Hollywood and Burbank), California (Tetra Tech, 2003). However, 1,2,3-TCP was essentially not detected in any soil gas samples above the detection limit of 1 µg/L (Appendix D). For this reason, ~~until additional sampling results are produced (What does this mean?)~~, soil gas surveys are not expected to be particularly effective for identifying 1,2,3-TCP sources. A combination of subsurface soil samples, groundwater sampling, and potentially soil gas sampling near suspected releases is expected to be the most effective approach to identify 1,2,3-TCP sources.

LARWQCB-lead investigations at facilities in the SGV where suspected releases of VOCs (e.g., TCE or PCE) have occurred typically begin with a soil gas survey, which has been

Formatted: Font color: Orange

shown to be an cost-effective strategy. However, because 1,2,3-TCP is less volatile than PCE or TCE (see Appendix A) and more difficult to detect, these limitations need to be considered when designing a soil gas survey to help locate potential 1,2,3-TCP releases. It is recommended that evaluation of operations at the facility or business be performed first, so that collection of soil gas samples can be focused ~~in on these~~ areas where an actual release may have occurred and therefore where elevated subsurface concentrations ~~associated with a release~~ are expected likely to occur. This approach may be more effective than using a sampling grid approach for screening a facility for potential 1,2,3-TCP releases.

## 5. Analytical Methods

A summary of recommended ~~analytical~~ methods for the analysis of 1,2,3-TCP in soil, soil gas, and groundwater, is provided in this section.

### 5.1 Groundwater

~~Because accepted collection methods (see Section 4) generally result in samples from monitoring or production wells with low levels of turbidity (e.g., less than 5 nephelometric turbidity units [NTUs]), most groundwater samples can be analyzed using methods developed for (unfiltered) drinking water (This is a very awkward sentence. Please revise. Also, I believe we mean to state the samples have low turbidity and not the wells). To allow laboratories to meet the DHS detection limit for reporting purposes (DLR) of 0.005 µg/L for 1,2,3-TCP (consistent with the NL of 0.005 µg/L), DHS has developed and approved two analytical methods which are DHS approved for analysis of water (including groundwater) samples for public (drinking) water systems that are capable of meeting the DHS detection limit for reporting purposes (DLR) of 0.005 µg/L for 1,2,3-TCP (consistent with the NL of 0.005 µg/L): methods DHS PT-GC/MS and DHS LLE-GC/MS. In addition two other alternative methods are DHS has approved the use of EPA methods 504.1 and 551.1 by if the laboratories that can demonstrate that it can meet achieve the DLR without implementing method modifications: EPA 504.1, and EPA 551.1. These four DHS approved methods are summarized in Table 5-1. EPA methods 504.1 and 55.1.1 are the older analytical methods that DHS continues to approve. It should be noted that when using EPA methods 504.1 or 551.1 on samples with high total dissolved solids (TDS) or VOC content or with other interferences that preclude unambiguous identification, these older methods, 1,2,3-TCP detections in a sample that has a high total dissolved solids (TDS) or VOC content, or otherwise precludes unambiguous confirmation, should be confirmed with one of the DHS GC/MS methods above. The DHS methods are recommended for definitive identification and quantification, especially for verifying the presence of 1,2,3-TCP at concentrations close to the NL.~~

Formatted: Font color: Orange

TABLE 5-1  
DHS-Approved Analytical Methods for 1,2,3-TCP in Water

Method	Detection Limit (µg/L)	Sample Container	Holding Time	Approximate Cost per Sample
DHS PT-GC/MS <sup>a</sup>	0.005	40-mL vial, HCl to pH <2;	14 days	\$150

TABLE 5-1  
DHS-Approved Analytical Methods for 1,2,3-TCP in Water

Method	Detection Limit (µg/L)	Sample Container	Holding Time	Approximate Cost per Sample
DHS LLE-GC/MS	0.005	cooled to 4°C 1-L amber bottle; cooled to 4°C	14 days before extraction; 24 hours for extract analysis	\$225
EPA 504.1	Varies by lab; typical detection limits in the past have been 0.02 µg/L	40-mL vial with sodium thiosulfate; cooled to 4°C	14 days before extraction; 24 hours for extract analysis	\$85
EPA 551.1	Varies by lab; one lab reported a 0.008 µg/L detection limit	60-mL vial with ammonium chloride; cooled to 4°C	14 days before extraction; 14 days for extract analysis	NA?? Does this mean free?! unknown

<sup>a</sup>Used by USEPA Region 9 for groundwater monitoring samples.

Based on ~~results in~~ EPA's San Gabriel Basin database, samples from essentially all of the active production wells in SGV Area 3, most of which are used to supply (unfiltered) drinking water, have been analyzed using one of the DHS methods (see Appendix C, UCMR).

For all of these methods, the laboratory should be provided with a statement of work (SOW) that defines the needed quality control (QC) for the analyses to ~~ensure that provide~~ ~~for~~ reproducible, comparable, and defensible data are generated. The quality control specifications should include requirements for initial and continuing calibration, instrument tuning, internal standards, laboratory control standard, matrix spikes, duplicates, method detection limits and documentation. The project-specific SOW should identify the specific quality control procedures, level of effort (the frequency of the runs), acceptable quality control limits, and corrective action requirements.

### DHS Analytical Methods

The DHS Sanitation and Radiation Laboratories (SRL) has developed two gas chromatography/mass spectrometry (GC/MS) methods (Purge and Trap GC/MS and Liquid-Liquid Extraction GC/MS) that are capable of 1,2,3-TCP quantification at the DLR. In February 2002, CA DHS published the two new analytical methods, listed below.

- *Determination of 1,2,3-Trichloropropane in Drinking Water by Purge and Trap Gas Chromatography/Mass Spectrometry* (DHS PT-GC/MS).  
<http://dhs.ca.gov/ps/ddwem/chemicals/unregulated/TCPbyPT-GCMS.pdf>
- *Determination of 1,2,3-Trichloropropane in Drinking Water by Continuous Liquid-Liquid Extraction and Gas Chromatography/Mass Spectrometry* (DHS LLE-GC/MS).  
<http://dhs.ca.gov/ps/ddwem/chemicals/unregulated/TCPbyLLE-GCMS.pdf>

Both methods use GC/MS in the selective (I think it may be "selected") ion monitoring (SIM) mode and isotope dilution to meet the low DLR. Quantitation is performed using isotope dilution with TCP-D5. The presence of VOCs that ~~which~~ co-elute or overlap with

TCP or TCP-D5, and ~~that which~~ yield the same fragment ions as TCP or TCP-D5, can be a major source of error in both these methods. Due to the extreme sensitivity of these methods, even low abundances of these ions can result in severe interference when the interfering compound is present at sufficiently high concentrations. The following compounds have the potential to interfere: trans-1,4-dichloro-2-butene (m/z 75 ion), isopropylbenzene (m/z 75 ion), o-xylene (m/z 79 ion). QC data for ~~the~~ individual sample batches should be reviewed to evaluate the impact of these interferences on analytical data.

The list of laboratories ~~that are~~ certified by DHS under the Environmental Laboratory Accreditation Program (ELAP) to perform 1,2,3-TCP analysis in drinking water is available at <http://www.dhs.ca.gov/ps/ls/elap/html/lablist.htm>.

### Older Analytical Methods

~~Due to the extremely low DHS DLR required to meet the NL for 1,2,3-TCP (0.005 µg/L or 5 ng/L), EPA methods 502.2, and 524.2 are not inappropriate for measuring this compound in drinking water, even though 1,2,3-TCP is listed as an analyte in the method descriptions. (This sentence is awkward.)~~ However, these methods have been used in the past for the analysis of 1,2,3-TCP in water or are currently in ~~use for which 1,2,3-TCP (I think a word may be missing here.)~~ is not the primary target analyte. The detection limits of these methods are considerably higher than the DHS DLR of 0.005 µg/L.

Formatted: Font color: Orange

Formatted: Font color: Orange

Formatted: Font color: Orange

Formatted: Font color: Orange

TABLE 5-2  
Other Analytical Methods for 1,2,3-TCP in Water

Method	Detection Limit	Sample Container	Holding Time	Approximate Cost per Sample
EPA 524.2 <sup>b</sup>	0.03 µg/L	40-mL vial with ascorbic acid <sup>a</sup> ; HCl to pH <2; cooled to 4°C	14 days	\$225 to \$275
502.2	0.4 µg/L	40-mL vial with ascorbic acid <sup>a</sup> ; HCl to pH <2; cooled to 4°C	14 days	\$110 to \$275

<sup>a</sup> Use of ascorbic acid is recommended in samples collected from some public drinking water systems to remove any chlorine that may be in the water. Ascorbic acid is a very weak acid that is not ~~be~~-suitable for lowering the pH of the sample (HCl is instead used for that purpose).

<sup>b</sup> EPA 524.2 has recently been used in the SIM mode for the analysis of 1,2,3-TCP with a the detection limit of 0.002 µg/L.

## 5.2 Soil

Recommended ~~analytical~~ methods for the analysis of 1,2,3-TCP in soil ~~samples~~ are provided in Table 5-3. California has not proposed reporting limits for 1,2,3-TCP in soils; ~~however, it is common to use EPA's preliminary remediation goals (PRGs) for soils are commonly used to establish as potential levels of concern that would set the upper boundary~~ of acceptable target reporting limits. The EPA Region 9 PRGs for 1,2,3-TCP are 0.034 mg/kg for ~~soil in residential areas~~ soil [10<sup>-6</sup> cancer risk] and 0.076 mg/kg for ~~soil in industrial areas~~ soil [10<sup>-6</sup> cancer risk](see Appendix C). As shown in Table 5-3, ~~analyses using detection limits for~~ EPA Methods 8021B and 8260B can meet these target reporting

limits. The detection limit cited for 1,2,3-TCP using EPA Method 8270C (Table 5-3) is ~~the expected reporting limit~~ an estimate based on analysis of similar compounds. To quantify 1,2,3-TCP at concentrations lower than below the EPA PRGs, the use of Method 8270C with would have to be run in SIM would be necessary to meet these target reporting limits.

TABLE 5-3  
Analytical Methods for 1,2,3-TCP in Soil

Method	Detection Limit (µg/kg)	Sample Container	Holding Time	Approximate Cost per Sample
EPA 8021B	Approximately 10 µg/kg	Encore sampler, brass or SS sleeve <sup>a</sup> , cooled to 4°C	14 days; otherwise analysis must be completed within 48 hours <del>if samples are not frozen prior to the expiration of the 48-hour period.</del> Sample should not be frozen below - 20°C due to potential problems with seals and the loss of constituents upon sample thawing.	\$150
EPA 8260B	Approximately 5 µg/kg <sup>b</sup>	Encore sampler, brass or SS sleeve <sup>a</sup> , cooled to 4°C	14 days; otherwise analysis must be completed within 48 hours <del>if samples are not frozen prior to the expiration of the 48-hour period.</del> Sample should not be frozen below - 20°C due to potential problems with seals and the loss of constituents upon sample thawing.	\$225 to \$350
EPA 8270C	Approximately 330 to 660 µg/kg	Encore sampler, brass or SS sleeve, cooled to 4°C	14 days; otherwise analysis must be completed within 48 hours <del>if samples are not frozen prior to the expiration of the 48-hour period.</del> Sample should not be frozen below - 20°C due to potential problems with seals and the loss of constituents upon sample thawing.	\$195

<sup>a</sup> To minimize analyte loss, EPA recommends collecting a soil sample in an Encore sampler, or extruding the sample into an empty sealed vial, cooling to 4 ± 2°C for no more than 48 hours, then freezing to -7°C upon laboratory receipt.

<sup>b</sup> By using selective (selected?) ion monitoring, the 8260 detection limits can be reduced by orders of magnitude.

No specific interferences have been identified for the (gas chromatographic?) columns (Is this meant to address the separation of analytes using GC? Unclear.) used for the methods presented in Table 5-3. However, matrix-specific interferences potentially may ~~potentially~~ be present.

### 5.3 Soil Gas

Soil gas surveys have been used to investigate suspected 1,2,3-TCP sources in groundwater basins like the SGV to a very limited extent. A ~~contractor performed a~~ soil gas investigation was performed at an aircraft industry facility in the San Fernando Valley Superfund Site (Area 1 - North Hollywood and Burbank), California. Soil vapor samples were analyzed using an unpublished procedure that involved and with a GC with a MS detector (GC/MS) in both "open scan" and SIM modes (Pavlick, 2005). Soil gas samples were collected as

either whole samples in SUMMA canisters or Tedlar bags, or on charcoal/tenax tubes. Soil gas samples were analyzed either directly or using a tenax trap to collect 1,2,3-TCP prior to desorption into the GC/MS. The sensitivity of this unpublished GC/MS SIM method was approximately 0.1 to 0.2 ppbV.

In this case, collection probes for the soil gas samples were placed at depths 20 to 30 feet? above the groundwater table near a monitoring well in which 1,2,3-TCP had been previously detected at concentrations of up to 200 µg/L (Tetra Tech, 2003) (Is this the same case study as the one discussed in the preceding paragraph? The citation makes it unclear.). Soil gas samples collected from these probes contained either very low, or no detectable, concentrations of 1,2,3-TCP. The contractor performing the analysis noted that the method (does this refer to the sampling method or the analytical method?) was reliable, but not robust enough to be used as a stand-alone procedure (This statement is confusing. Can we reword it?), because groundwater and soil analytical results did not correlate well to the soil gas analytical results. Ultimately, the contractor concluded that, until further soil gas analysis research was performed, soil gas analysis for 1,2,3-TCP should be combined with 1,2,3-TCP analysis of samples of soil and groundwater from the facility, to confirm have sufficient understanding of the presence or/ the absence of 1,2,3-TCP.

Formatted: Font color: Orange

Formatted: Font color: Orange

Methods for soil gas analysis should be selected based on a function of the sampling method chosen (i.e., passive or active) and the intended use of the data collected. Field analysis using portable instrumentation, such as GC and/or or GC/MS, may be performed, usually by a mobile laboratory, or samples may be shipped to an off-site laboratory. Off-site laboratory analysis is generally is more expensive, but also more reliable, because more rigorous quality control procedures are in place.

Currently, there are limited information and data regarding the sampling and analysis of 1,2,3-TCP in soil vapor/ambient air are limited. NIOSH method 1003 is currently used for monitoring worker exposure in ambient air. The NIOSH method for off-site laboratory analysis involves extraction of the sample on a solid sorbent with carbon disulfide, and analysis by GC with a flame ionization detector (FID). The method requires the use of a charcoal tube for sample collection and analysis by a GC/FID, with a reporting limit of roughly 1 ppmV. This NIOSH method lacks the sensitivity and selectivity required for most facility source investigations. Table 5-4 below summarizes the methods that are available for 1,2,3-TCP analysis of soil gas. Method modifications to meet the project- or site-specific detection limits may need to be evaluated and considered.

**TABLE 5-4 (NOTE: COLUMN HEADERS ARE NOT SHOWING UP AFTER PAGE BREAK)**  
Analytical Methods for 1,2,3-TCP in Soil Gas

Method	Detection Limit	Sample Container	Holding Time	Approximate Cost per Sample
EPA 8260B	1 µg/L - vapor	Amber gas-tight glass bulb or SUMMA canister	4 hours for amber gas-tight glass bulb; 72 hours for SUMMA canister <sup>a</sup>	NA
NIOSH 1003	0.01 mg/sample	Solid sorbent	None published, but analysis should be done as soon as possible to minimize analyte loss	NA

TABLE 5-4 (NOTE: COLUMN HEADERS ARE NOT SHOWING UP AFTER PAGE BREAK)  
Analytical Methods for 1,2,3-TCP in Soil Gas

Method	Detection Limit	Sample Container	Holding Time	Approximate Cost per Sample
EPA 8260B	1 µg/L - vapor	Amber gas-tight glass bulb or SUMMA canister	4 hours for amber gas-tight glass bulb; 72 hours for SUMMA canister <sup>a</sup>	NA
NIOSH 1003	0.01 mg/sample	Solid sorbent	None published, but analysis should be done as soon as possible to minimize analyte loss	NA
EPA TO-15	0.050 µg/m <sup>3</sup>	SUMMA canister	30 days	\$125

<sup>a</sup>LARWQCB requirement.

## 6 Remediation and Treatment

### 6.1 Remediation

Only limited information is available on remediation of 1,2,3-TCP contamination. Potential remediation approaches are summarized below in Table 6-1.

TABLE 6-1  
Remediation Approaches for 1,2,3-TCP Contamination

Approach	Media	Description
Pump and Treat	Groundwater	Effective for containment or source control. Not expected to be cost effective for source remediation. See Table 6-2 for groundwater treatment approaches.
In Situ Vacuum Extraction and In Situ Oxidation.	Soil, Soil Gas (vapor), and Groundwater	Full-scale remediation of soils, bedrock, and groundwater is underway at the Tyson Superfund Site near Philadelphia, Pennsylvania, using in situ vacuum extraction of silty clay soils, dual extraction of water and vapor from underlying fractured sandstone, and collection and treatment of seep water. Vapor treatment uses activated carbon adsorption (Pezullo et al., 2005). Oxidants have been injected into the subsurface in areas of DNAPL containing 1,2,3-TCP to oxidize contaminants in the subsurface. The more volatile byproducts from the oxidation reactions are captured by the vacuum extraction system that is designed to recover these byproducts. It should be noted that because the Henry's Law constant for 1,2,3-TCP ( <u>units? 3 x 10<sup>-4</sup></u> ) is below the 10 <sup>-3</sup> threshold commonly used to assess application of soil vapor extraction (SVE) as a stand-alone remedial alternative, vacuum extraction may not be the most effective remedial approach (see Appendix D, MacKenzie Chemical Works site). This technique is applicable to soil gas concentrations from tens to thousands of ug/-m <sup>3</sup> and total soil VOC concentrations <u>of up to hundreds of thousands of mg/kg. (Can we clarify this? Aren't these percentage levels?)</u>
Dechlorination by Hydrogen Releasing Compounds	Groundwater	Use of Hydrogen Release Compound (HRC®) for in situ treatment of 1,2,3-TCP resulted in 99.9% reduction over 1,000 days at <u>an unname</u> site in California (Reilly, 2005). HRC has also been used at the John Taylor Fertilizers Company in Yuba City, CA (CRWQCB, 2004) and Western Farm Service, Inc. (CRWQCB,

Formatted: Font color: Orange

TABLE 6-1  
Remediation Approaches for 1,2,3-TCP Contamination

Approach	Media	Description
Permeable Reactive Barrier (PRB)	Groundwater	<p>2002). HRC is a product designed for in situ treatment of chlorinated solvents or any anaerobically degradable substance. HRC slowly hydrolyzes releasing lactic acid, which is utilized by microbes to produce hydrogen, thereby inducing reductive dechlorination. This technique is applicable to concentrations ranging from less than 1 µg/L to 1 mg/L.</p> <p><del>Zero-valent iron has been shown to reduce</del> 1,2,3-TCP <del>has been shown to be reduced by zero-valent iron</del>. Therefore, the application of permeable reactive <del>ion</del> barrier (PRB) technology may be a viable <del>for approach to</del> remediation of a shallow 1,2,3-TCP plume (Focht and Gillham, 1995; Vidic and Pohland, 1996). Others have described the feasibility of using a PRB for remediation of 1,2,3-TCP in groundwater (USEPA, 1998).</p> <p>EnviroMetal Technologies, Inc. (ETI) has performed bench column testing to treat 1,2,3-TCP in groundwater. Treatability testing involved water from a site in California and use of a 100 percent commercially available granular iron supply. The influent concentration of 437 µg/L 1,2,3-TCP declined to non-detectable concentrations during a 12-hour residence time at room temperature (ETI, 2005). Based on this testing, ETI <del>is</del> recommends <del>ing</del> the application of a granular iron PRB to treat 1,2,3-TCP groundwater contamination.</p> <p>Given the depth to groundwater in SGV Area 3 (275 to 300 feet bgs), a PRB could not be installed via a trench, but would likely need to be installed by injecting the materials into the subsurface via closely spaced wells.</p>
In Situ Biodegradation	Groundwater	<p>1,2,3-TCP <del>is was</del> not readily biodegradable <del>under in</del> aerobic <del>conditions biodegradation tests</del> and is only slowly transformed by bacteria under aerobic and anaerobic conditions (WHO, 2003). Bosma (2002) has genetically engineered a strain of bacteria that can utilize 1,2,3-TCP as a food source. However, the microbial activity is insufficient to sustain bacterial growth. Peijnenburg, et al. (1998) observed the reductive dehalogenation of 1,2,3-TCP in anaerobic sediments. See Appendix A for additional discussion of 1,2,3-TCP biodegradation.</p>
SERDP Initiatives	Groundwater	<p>The U.S. Department of Defense's Strategic Environmental Response and Development Program (SERDP) sponsors initiatives for innovative remediation approaches. The SERDP currently (April 2005) has a project (CU-1457) listed on their website (<a href="http://www.serdp.org/research/Cleanup.html">http://www.serdp.org/research/Cleanup.html</a>) which involves investigating prospects for remediation of 1,2,3-TCP by natural and engineered abiotic degradation reactions.</p>

It should be noted that the effectiveness of the remediation approaches presented in Table 6-1 at ~~the low (about 400 ng/L or less)~~ 1,2,3-TCP concentrations, ~~such as those~~ observed in SGV Area 3 ~~(about 400 ng/L or less)~~, ~~needs to be further~~ ~~has not been~~ assessed ~~at the present time~~. Such an assessment will require significantly more effort than ~~that allotted for expended in~~ preparation of this interim guidance document.

## 6.2 Treatment

Although treatment of 1,2,3-TCP in groundwater is underway at some contaminated sites in the U.S., only limited information regarding the technologies is available at this time. The initial screening of groundwater treatment technologies presented below was prepared based on experience at the San Fernando Valley Superfund Site (Area 1 - North Hollywood and Burbank), California.

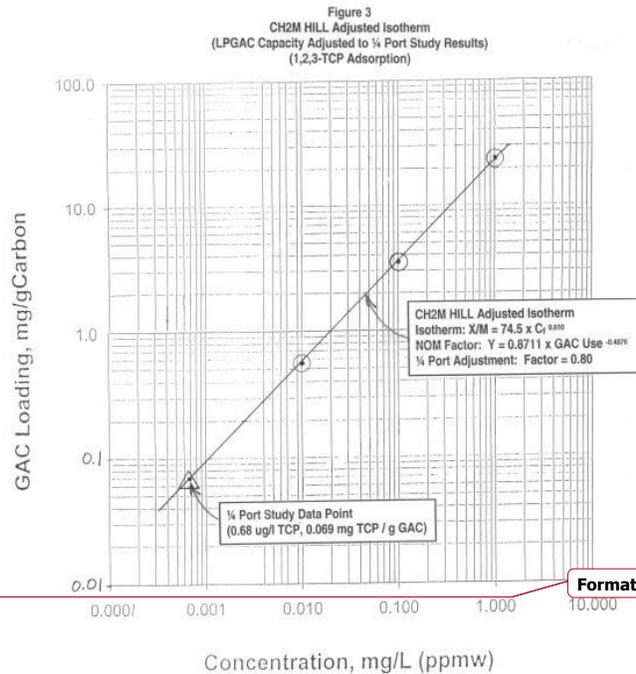
**TABLE 6-2**  
Ex-Situ Groundwater Treatment Technology Screening for Removal of 1,2,3-TCP

Treatment Technology	Application Performance Opinion
Air Stripping	Poor
Liquid-Phase Granular Activated Carbon Adsorption	Very Good
Advanced Oxidation	Poor
Biological Reduction	Poor
Ion Exchange	NA
Reverse Osmosis	Fair
Zero Valent Iron Dechlorination	Fair
NA – Not applicable	

### Key Treatment Technology Discussion:

Ex-situ treatment using liquid-phase granular carbon adsorption (LGAC) is **the technology that is** in use for treatment of 1,2,3-TCP in groundwater at the San Fernando Valley Superfund Site (Area 1 - North Hollywood and Burbank), California. The **isotherm** figure to the right presents an isotherm developed for 1,2,3-TCP using site-specific rapid small scale column test data provided by Calgon Corporation and full-scale site data from the San Fernando Valley Superfund Site (Area 1 - North Hollywood and Burbank), California..

Typical LGAC vessel design flux (5 to 8 gallons per minute (gpm)/square foot) and empty bed contact time (10 minutes) assumptions are used. **Treatment of 1,2,3-TCP using LGAC appears to have an unusually long**



Formatted: Font color: Orange

---

mass transfer zone (The grammar in this sentence seems off: "Treatment ... appears to have an unusually long mass transfer zone"?), which results in earlier breakthrough than most common VOCs (e.g., TCE and PCE).

### Advanced Oxidation

The HiperOxidation™ (HiPOx™) process has been in use for treatment of ~~primarily~~ ~~m~~Methyl ~~t~~Tert-~~b~~Butyl ~~e~~Ether (MTBE), ~~commingled~~ with ~~comparatively~~ minor concentrations of 1,2,3-TCP, at the former Marine Corps Air Station (MCAS) Tustin underground storage tank (UST) Site 222 (NAVFAC, 2003). As of 2003, nearly 2,910 pounds of MTBE and 1 pound of 1,2,3-TCP had been removed from groundwater at the former MCAS Tustin. Based on experience at the former MCAS Tustin, the cost of operating the HiPOx™ treatment system is nearly 3 times the cost of operating a LGAC system for treatment of the 1,2,3-TCP groundwater contamination. Additional detail on the operation of the HiPOx system to treat / remove 1,2,3-TCP and other chlorinated solvents in groundwater is provided by Dombeck (2005).

## 7. References

### USES AND MANUFACTURERS

Kirk Othmer Encyclopedia of Chemical Technology, January 2001.

National Toxicity Program, 2005. Report on Carcinogens, Eleventh Edition, Substance Profiles, 1,2,3-Trichloropropane. U.S. Department of Health and Human Services, Public Health Service, National Toxicology Program, January 2005. <http://ntp-server.niehs.nih.gov/ntp/roc/eleventh/profiles/s182tcp.pdf>.

World Health Organization (WHO), 2003. Concise International Chemical Assessment Document 56, 1,2,3-Trichloropropane. <http://www.inchem.org/documents/cicads/cicads/cicad56.htm>.

### SAMPLING

California Water Quality Control Board, Los Angeles Region, and Department of Toxic Substances Control, 2003. Advisory, Soil Gas Investigations. January 28, 2003. [http://www.dtsc.ca.gov/PolicyAndProcedures/SiteCleanup/SMBR\\_ADV\\_activesoilgasinvst.pdf](http://www.dtsc.ca.gov/PolicyAndProcedures/SiteCleanup/SMBR_ADV_activesoilgasinvst.pdf).

Genau, Bob, April 2001. Field Reference, Diffusion Bag Samplers. DuPont Corporate Remediation Group. <http://www.diffusionsampler.org/Documents/Genau%202002%20Field%20References%20DBS.pdf>.

ITRC, Interstate Technology & Regulatory Council Diffusion Sampler Team, 2004. Technical and Regulatory Guidance for Using Polyethylene Diffusion Bag Samplers to Monitor Volatile Organic Compounds in Groundwater. February 2004. <http://www.itrcweb.org/documents/DSP-3.pdf>.

---

Tetra Tech, 2003. Evaluation of 1,2,3-Trichloropropane within the Burbank Operable Unit, Burbank, California. Prepared for Lockheed Martin. May 30, 2003.

Vroblesky and Campbell, 2001. User's Guide for Polyethylene Based Passive Diffusion Bag Sampler to Obtain Organic Concentrations in Wells. March 2001.

### **ANALYTICAL METHODS**

California Department of Health Services, March 7, 2005. 1,2,3-Trichloropropane: Notification Level & Monitoring Results.

<http://www.dhs.ca.gov/ps/ddwem/chemicals/123tcp/notificationlevel.htm>.

California Department of Health Services, Environmental Laboratory Accreditation Program (ELAP). Laboratories Certified for 1,2,3-Trichloropropane (123-TCP) analysis in Drinking Water. Last updated 1/5/2005.

[http://www.dhs.ca.gov/ps/ls/elap/lab\\_lists/LabList\\_DW123TCP.xls](http://www.dhs.ca.gov/ps/ls/elap/lab_lists/LabList_DW123TCP.xls).

California Department of Health Services. Analysis for 1,2,3-TCP. Last Updated March 7, 2003. <http://www.dhs.ca.gov/ps/ddwem/chemicals/unregulated/123TCPanalysis.htm>.

Pavlick, Raphe (HydroGeoSpectrum, Inc.), April 25, 2005. Personal communication with CH2M HILL regarding soil gas sampling in the San Fernando Valley Superfund Site (Area 1 - North Hollywood and Burbank), California.

### **REMEDIATION/TREATMENT**

Bosma, Tjibbe, 2002. Engineering bacteria for the degradation of halopropanes. Dissertation, University of Groningen, Netherlands.

<http://dissertations.ub.rug.nl/faculties/science/2002/t.bosma/>.

California Regional Water Quality Control Board, Central Valley Region (CRWQB). 2005. Order No. R5-2004-0055. Waste Discharge Requirements for John Taylor Fertilizers Co. Yuba City Facility, Enhanced Bioremediation Project, Sutter County.

[http://www.waterboards.ca.gov/centralvalley/adopted\\_orders/Sutter/R5-2004-0055.pdf](http://www.waterboards.ca.gov/centralvalley/adopted_orders/Sutter/R5-2004-0055.pdf).

California Regional Water Quality Control Board, Central Valley Region. 2002. Order No. R5-2002-0143. Waster Discharge Requirements for Western Farm Service Inc. Merced Facility, In situ Groundwater Remediation Pilot Study, Merced County.

[http://www.waterboards.ca.gov/centralvalley/adopted\\_orders/Merced/R5-2002-0143.pdf](http://www.waterboards.ca.gov/centralvalley/adopted_orders/Merced/R5-2002-0143.pdf).

Dombeck, Glen, May 26-27, 2005. "Multicontaminant Treatment for 1,2,3-TCP Destruction Using the HiPOx Reactor." - NGWA's MTBE & Perchlorate: Assessment, Remediation, and Public Policy Conference.

---

EnviroMetal Technologies, Inc. (ETI). 2005. Email communication from Stephanie O'Hannesin/ETI to CH2M HILL. April 18, 2005.

Focht, R.M. and Gillham, R.W., 1995. "Dechlorination of 1,2,3-Trichloropropane by Zero-Valent Iron." Proceedings of 209<sup>th</sup> ACS National Meeting, Anaheim, CA, April 2-7, 741-744.

NAVFAC Southwest Division, August 23, 2003. Restoration Advisory Board (RAB) Minutes for MCAS Tustin.

<http://www.efds.w.navy.mil/environmental/Pages/tusmin54.htm>.

Peijnenburg, W., Eriksson, L., De Groot, A., Sjöström, M., and Verboom, H., 1998. The Kinetics of Reductive Dehalogenation of a set of Halogenated Aliphatic Hydrocarbons in Anaerobic Slurries. *Environmental Science & Pollution Research*, 5(1): 12-16.

Pezullo, Joseph, Peterson, R., and Malot, J., 2005. Full-Scale Remediation at a Superfund Site using In Situ Vacuum Remediation and On-Site Regeneration Case Study – Phase I.

<http://www.terravac.com/web/cases.htm#tyson>.

Reilly, Dave (Regenesys Corporation), May 25, 2005. Personal Communication with CH2M HILL regarding use of HRC for in situ treatment of 1,2,3-TCP.

Terravac, 2005. <http://terravac.com/web/papers.htm>.

Vidic, Radisav and Frederick Pohland, 1996. Treatment Walls, Technology Evaluation Report TE-96-01, Ground-Water Remediation Technologies Analysis Center. October 1996.

[http://www.epa.gov/tio/download/remed/tmt\\_wall.pdf](http://www.epa.gov/tio/download/remed/tmt_wall.pdf).

SERDP Cleanup Projects. Last updated 4/19/2005.

<http://www.serdp.org/research/Cleanup.html>.

Western Farm in situ GW remediation.

[http://www.waterboards.ca.gov/centralvalley/adopted\\_orders/Merced/R5-2002-0143.pdf](http://www.waterboards.ca.gov/centralvalley/adopted_orders/Merced/R5-2002-0143.pdf).

USEPA, September 1998. Office of Research and Development, Office of Solid Waste and Emergency Response. EPA/600/R-98/125. Permeable Reactive Barrier Technologies for Contaminant Remediation. <http://clu-in.org/download/rtdf/prb/reactbar.pdf>.

## **CHEMICAL PROPERTIES**

Agency for Toxic Substances and Disease Registry (ATSDR), September 1992. Toxicological Profile Information Sheet for 1,2,3-Trichloropropane.

<http://www.atsdr.cdc.gov/toxprofiles/tp57.html>.

Lyman, W.J., W.F., Reehl, and D.D. Rosenblatt, 1982. Environmental Behavior of Organic Compounds. McGraw-Hill, New York.

Mackay, D., Shiu, W., and Ma, K., 1993. Illustrated Handbook of Physical-Chemical Properties and Environmental Fate for Organic Chemicals, Vol. 3, Volatile Organic Chemicals. Boca Raton, FL, Lewis Publishers.

---

National Safety Council, Chemical Backgrounders, 1,2,3-Trichloropropane Chemical Backgrounder. <http://www.nsc.org/library/chemical/123trich.htm>.

NIOSH Pocket Guide to Chemical Hazards, 1,2,3-Trichloropropane. <http://www.cdc.gov/niosh/npg/npgd0631.html>.

NIST Chemical Database, Henry's Law Constants for 1,2,3-Trichloropropane. <http://webbook.nist.gov/cgi/cbook.cgi?ID=C96184&Units=SI&Mask=10#Solubility>.

U.S. Coast Guard. Chemical Hazard Response Information System (CHRIS), 1,2,3-Trichloropropane. <http://www.chrismanual.com/T/TCN.pdf>.

Verschueren, K, 1996. *Handbook of Environmental Data on Organic Chemicals*, 3rd ed. New York, NY, John Wiley & Sons.

### **ENVIRONMENTAL FATE AND TRANSPORT**

Anderson, T.A., Beauchamp, J.J., and Walton, B.T., 1991. Fate of volatile and semivolatile organic chemicals in soils: Abiotic versus biotic losses. *Journal of Environmental Quality*, 20(2):420-424.

Bosma, T and Janssen, D.B., 1998. Conversion of chlorinated propanes by *Methylosinus trichosporium* OB3b expressing soluble methane monooxygenase. *Applied Microbiology and Biotechnology*, 50:105-112.

Peijnenburg, W., Eriksson, L., De Groot, A., Sjöström, M., and Verboom, H., 1998. The Kinetics of Reductive Dehalogenation of a set of Halogenated Aliphatic Hydrocarbons in Anaerobic Slurries. *Environmental Science & Pollution Research*, 5(1): 12-16.

Vannelli T, Logan, M, Arciero, D, and Hooper, A, 1990. Degradation of halogenated aliphatic compounds by the ammonia-oxidizing bacterium *Nitrosomonas europaea*. *Applied Environmental Microbiology*, 56(4):1169-1171.

World Health Organization (WHO), 2003. Concise International Chemical Assessment Document 56, 1,2,3-Trichloropropane. <http://www.inchem.org/documents/cicads/cicads/cicad56.htm>.

### **REGULATORY LEVELS**

California Water Quality Control Board, Central Valley Region, 2003. A Compilation of Water Quality Goals. August 2003. [http://www.swrcb.ca.gov/rwqcb5/available\\_documents/wq\\_goals/index.html#anchor358554](http://www.swrcb.ca.gov/rwqcb5/available_documents/wq_goals/index.html#anchor358554).

Marshack, Jon D, 2003. California Regional Water Quality Control Board, Central Valley Region. A Compilation of Water Quality Goals. [http://www.swrcb.ca.gov/rwqcb5/available\\_documents/wq\\_goals/index.html#anchor274991](http://www.swrcb.ca.gov/rwqcb5/available_documents/wq_goals/index.html#anchor274991).

---

USEPA, Region 9, October 2004. Preliminary Remediation Goals.  
<http://www.epa.gov/region09/waste/sfund/prg/index.htm>.

### **OCCURENCES OF ENVIRONMENTAL CONTAMINATION**

ATSDR, 2004. Public Health Assessment, Former Mackenzie Chemical Works Site, Central Islip, Suffolk County, New York, EPA Facility Id: Nyd980753420, September 29, 2004.  
<http://www.atsdr.cdc.gov/HAC/PHA/mackenzie092904/mackenzie092904-p3.html>.

City of Shafter, California, 2000. City of Shafter Consumer Confidence Report for Water Quality, pp.1-6.

Environmental Defense, Scorecard, Environmental Releases, Facilities with Total Reported Environmental Releases, 1,2,3-Trichloropropane. [http://www.scorecard.org/chemical-profiles/rank-facilities.tcl?edf\\_chem\\_name=1%2C2%2C3-TRICHLOROPROPANE&edf\\_substance\\_id=96-18-4&how\\_many=100&drop\\_down\\_name=Total+environmental+releases&fips\\_state\\_code=Enfire+United+States&sic\\_2=All+reporting+sectors](http://www.scorecard.org/chemical-profiles/rank-facilities.tcl?edf_chem_name=1%2C2%2C3-TRICHLOROPROPANE&edf_substance_id=96-18-4&how_many=100&drop_down_name=Total+environmental+releases&fips_state_code=Enfire+United+States&sic_2=All+reporting+sectors).

Howe, Roberta C (Visalia District, California Department of Health Services, Drinking Water Field Operations Branch, Los Angeles, California), Nov. 12, 1999. Memorandum: 1,2,3-Trichloropropane Investigation.

Johnson, R., 1968. Polymers containing sulfur. Polysulfides. In: *Kirk-Othmer Encyclopedia of chemical technology*, 2<sup>nd</sup> ed. New York, NY, John Wiley & Sons, pp.253-254, 259-262.

New Jersey Department of Environmental Protection, Cumberland County Index of Sites (with Groundwater Contamination), 2002.  
[http://www.nj.gov/dep/srp/publications/site\\_status/2002/pdf/cumberland.pdf](http://www.nj.gov/dep/srp/publications/site_status/2002/pdf/cumberland.pdf).

Scorecard, the Pollution Information Site. Facilities with Reported Total Environmental Releases in 2002. [http://www.scorecard.org/chemical-profiles/rank-facilities.tcl?edf\\_substance\\_id=96%2d18%2d4&edf\\_chem\\_name=1%2c2%2c3%2dTRICHLOROPROPANE&type=mass&category=total\\_env&modifier=na&fips\\_state\\_code=Entire%20United%20States&sic\\_2=All%20reporting%20sectors&how\\_many=100](http://www.scorecard.org/chemical-profiles/rank-facilities.tcl?edf_substance_id=96%2d18%2d4&edf_chem_name=1%2c2%2c3%2dTRICHLOROPROPANE&type=mass&category=total_env&modifier=na&fips_state_code=Entire%20United%20States&sic_2=All%20reporting%20sectors&how_many=100).

Steppek, Jan (California Department of Health Services), June 2, 2003. Draft Groundwater Data Sheet, 1,2,3-Trichloropropane (TCP).  
[http://www.waterboards.ca.gov/gama/docs/tcp\\_jun2003.pdf](http://www.waterboards.ca.gov/gama/docs/tcp_jun2003.pdf). Note that Mr. Stepek was contacted during preparation of this guidance document.

Tetra Tech, 2003. Evaluation of 1,2,3-Trichloropropane within the Burbank Operable Unit, Burbank, California. Prepared for Lockheed Martin. May 30, 2003.

USEPA, 2001. NPL Site Narrative for MacKenzie Chemical Works, Inc. Federal Register Notice, Sept 13, 2001. <http://www.epa.gov/superfund/sites/npl/nar1631.htm>.

USEPA, Region 2, Sept 29, 2000. Ciba-Geigy Superfund Site Record of Decision Operable Unit 2. <http://www.epa.gov/region02/superfund/npl/ciba/ciba929.htm>.

---

USEPA, Region 2, June 15, 2000. Superfund Program Proposed Plan, Ciba-Geigy Chemical Corporation Site. <http://www.epa.gov/region02/superfund/npl/ciba/ciba615.htm>.

USEPA, Region 3, May 2004. Tyson's Dump Current Site Information.

USEPA, Region 4, July 1995. Record of Decision, Ciba-Geigy Corporation Superfund Site, Operable Unit #3 McIntosh Facility, McIntosh, Washington County, Alabama. <http://www.epa.gov/superfund/sites/rods/fulltext/r0495244.pdf>.

<http://www.epa.gov/reg3hwmd/npl/PAD980692024.htm>.

USEPA Toxic Release Inventory (TRI), List of EPA-Regulated Facilities in TRI.

[http://oaspub.epa.gov/enviro/fii\\_master.fii\\_retrieve?fac\\_search=primary\\_name&fac\\_value=&fac\\_search\\_type=Beginning+With&postal\\_code=&location\\_address=&add\\_search\\_type=Beginning+With&city\\_name=&county\\_name=&state\\_code=&epa\\_region\\_code=&sic\\_code=&all\\_programs=NO&sic\\_code\\_desc=&chem\\_name=1%2C2%2C3-trichloropropane&chem\\_search=Beginning+With&cas\\_num=&program\\_search=2&page\\_no=1&output\\_sql\\_switch=TRUE&report=1&database\\_type=TRIS](http://oaspub.epa.gov/enviro/fii_master.fii_retrieve?fac_search=primary_name&fac_value=&fac_search_type=Beginning+With&postal_code=&location_address=&add_search_type=Beginning+With&city_name=&county_name=&state_code=&epa_region_code=&sic_code=&all_programs=NO&sic_code_desc=&chem_name=1%2C2%2C3-trichloropropane&chem_search=Beginning+With&cas_num=&program_search=2&page_no=1&output_sql_switch=TRUE&report=1&database_type=TRIS).

Werkmeister, Jim (Bechtel, Inc.), June 1, 2005. Personal communication with CH2M HILL regarding 1,2,3-TCP at the Marine Corps Air Station Tustin, Orange County, California.

Zebarth, B.J., Szeto, S.Y., Hii, B., Liebscher, H, and Grove, G. 1998. Groundwater Contamination by Chlorinated Hydrocarbon Impurities in Soil Fumigant Formulations. Water Quality Research Journal of Canada, 33(1): 31-50.

## **HEALTH RISK**

Agency for Toxic Substances and Disease Registry (ATSDR), September 1992. Toxicological Profile Information Sheet for 1,2,3-Trichloropropane.

<http://www.atsdr.cdc.gov/toxprofiles/tp57.html>.

US Environmental Protection Agency (USEPA), 1997. Health Effects Advisory Summary Tables (HEAST), FY 1997 Update, US Environmental Protection Agency, Solid Waste and Emergency Response, 9200.6-303 (97-1), EPA-540-R-97-036, July 1997.

USEPA, April 2001. Integrated Risk Information System (IRIS). IRIS Summaries. 1,2,3-Trichloropropane (CASRN 96-18-4). <http://www.epa.gov/iris/subst/0200.htm>.

USEPA, 2005. Consumer Fact Sheet on Epichlorohydrin.

[http://www.epa.gov/safewater/contaminants/dw\\_contamfs/epichlor.html](http://www.epa.gov/safewater/contaminants/dw_contamfs/epichlor.html).

## Appendices

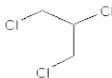
---

# Chemical Properties/Environmental Fate and Transport

## Chemical Properties

1,2,3-Trichloropropane (1,2,3-TCP), which can be referred to using a variety of chemical names and identifiers (Table A-1), is a non-polar chlorinated alkane that is soluble in alcohol, ether, and chloroform and is slightly soluble in water. It dissolves oils, waxes, fats, chlorinated rubber and numerous resins. It is sensitive to prolonged exposure to light and heat. It is reactive with chemically active metals, strong caustics, and oxidizers. When heated to decomposition, it yields highly toxic fumes of carbon monoxide, carbon dioxide, hydrogen chloride, phosgene, and other chlorinated compounds. Table A-2 lists chemical properties of 1,2,3-TCP and [specifies](#) how these properties relate to the behavior of 1,2,3-TCP in the environment.

**Formula:** C<sub>3</sub>H<sub>5</sub>Cl<sub>3</sub>



### Chemical Structure:

TABLE A-1  
Chemical Names and Identifiers

Item	Description	Comments
Synonyms	allyl trichloride	These <a href="#">terms</a> may turn up during investigation into potential 1,2,3-TCP uses at Area 3 facilities/businesses.
	glycerin trichlorohydrin	
	glycerol trichlorohydrin	
	glyceryl trichlorohydrin	
	trichlorohydrin	
	trichloropropane	
	1,2,3-TCP	
	TCP	

Identifiers	United Nations No.: 2810 Chemical Abstract System (CAS) Registry No.: 96-18-4 Chemical Hazard Response Information System (CHRIS): TCN Storet No.: 7743	These may turn up during investigation into potential 1,2,3-TCP uses at Area 3 facilities/businesses.
-------------	--	---

TABLE A-2  
Chemical Properties of 1,2,3-TCP

Property	Value	Reference	Environmental Efficacy
Molecular Weight	147.44 g	Verschueren, 1996	
Density at 20°C (Water = 1)	1.42 g/cm <sup>3</sup>	Verschueren, 1996	More dense than groundwater, can act as DNAPL.
Boiling Point	156 °C	WHO, 2003	Liquid at room temperature.
Melting Point	-14.7 °C	WHO, 2003	
Vapor Pressure at 25°C	3.1 mm Hg	ATSDR, 1992	Evaporates quickly at ambient temperatures; can be removed from surface water by evaporation.
Air Saturation at 20°C	16 g/m <sup>3</sup>	Verschueren, 1996	
Relative Vapor Density (Air=1)	5.1	WHO, 2003	Vapor is more dense than air, can accumulate above the water table.
Henry's Law Constant at 25°C	2.8 to 4.4 mol/kg*bar	NIST database	Volatile, but does not volatilize as readily as PCE, TCE; moderate volatilization from either dry or moist soil to the atmosphere.
	22.83 Pa-m <sup>3</sup> /mol	WHO, 2003	
	3.17 x 10 <sup>-4</sup> atm-m <sup>3</sup> /mol	ATSDR, 1992	
Solubility at 25°C	1.75 g/L	WHO, 2003	Relatively insoluble, but up to 1,750 mg/L (1,750,000 µg/L) may be present in water.
Octanol/Water Partition Coefficient (log K <sub>ow</sub> )	2.54 (calculated)	WHO, 2003	The low K <sub>ow</sub> value indicates that 1,2,3-TCP is mobile in the environment.
	2.27 (measured)	WHO, 2003	
	1.98	ATSDR, 1992	
Organic Carbon Partition Coefficient (log K <sub>oc</sub> )	68	NYSDEC (2005)	<del>is expected</del> to display high mobility in soil, and therefore has the potential to leach into groundwater primarily as 1,2,3-TCP.
	98 (calc. from solubility)	Lyman, et al. (1982)	

Table A-3 lists selected properties of 1,2,3-TCP relative to the properties of PCE, TCE, and 1,4-dioxane. Because PCE and TCE are the most prevalent VOCs in groundwater in SGV Area 3, comparing ~~ngen of~~ the properties of 1,2,3-TCP to the properties of these VOCs can

~~be provide useful information in predicting assessing the fate and transport of, and possible treatment options for~~ 1,2,3-TCP in SGV Area 3.

Based on the organic carbon partition coefficients,  $K_{oc}$ , shown in Table A-3, 1,2,3-TCP is more mobile in groundwater than PCE and TCE. The higher the  $K_{oc}$  value, the greater extent to which the chemical is adsorbed to organic material in the subsurface. Because 1,2,3-TCP has a lower  $K_{oc}$  value, it will adsorb to subsurface materials less readily than PCE or TCE and will travel at a rate closer to the same rate as the average groundwater velocity compared to PCE and TCE. In this manner, releases of these chemicals to groundwater should result in 1,2,3-TCP released in groundwater should migrate further downgradient of a source compared to PCE and TCE. In addition, the solubility of 1,2,3-TCP is more soluble higher than that for PCE and TCE, therefore, higher initial concentrations in groundwater are possible. Lower vapor pressure and Henry's Law Constant values indicate that 1,2,3-TCP is comparatively more difficult to detect in soil gas than PCE and TCE and would be much more difficult to treat by air stripping. If present in vadose zone soil, 1,2,3-TCP can be expected to will preferentially reside in pore moisture based on its chemical properties. Once in the environment, 1,2,3-TCP is likely to display similar be as resistance to aerobic biodegradation as PCE and/or TCE.

## Environmental Fate and Transport

### Abiotic Transformations

A calculated half life of 27.2 to 30.5 days for 1,2,3-TCP in the atmosphere has been reported. Therefore, 1,2,3-TCP released in the atmosphere might undergo very slow degradation in the presence of a sufficient concentration of photochemically produced hydroxyl radicals. Hydrolysis of 1,2,3-TCP in air appears to be of minor importance, with calculated half lives of 44 and 74 years (WHO, 2003).

### Biotransformation and Degradation

~~1,2,3-TCP does not readily biodegrade in tests conducted under aerobic conditions~~ biodegradation tests, 1,2,3-TCP was not readily biodegradable. In a preliminary study, the co-oxidative transformation of 1,2,3-TCP by the ammonia oxidizing bacterium *Nitrosomonas europaea* was shown (Vanelli et al., 1990). More recent studies employing the methanotroph *Methylosinus trichosporium* demonstrated that 1,2,3-TCP is co-metabolized to a range of different chemicals, such as chlorinated propanols (Bosma and Janssen, 1998). However, attempts to isolate bacterial? cultures that utilize 1,2,3-TCP as a sole source of carbon and energy have failed (WHO, 2003). Peijnenburg et al (1998) observed the reductive transformation of 1,2,3-TCP in anaerobic sediments, and determined that reductive dehalogenation was the sole reaction taking place. Anderson et al. (1991) reported a lack of biodegradation of 1,2,3-TCP in clay loam.

For soil fumigants containing 1,3-dichloropropene and chloropropanes, biodegradation appears to be much more significant for 1,3-dichloropropene than either 1,2-dichloropropane or 1,2,3-TCP. 1,3-Dichloropropene in the vapor-phase, will react with air, as well as volatilize, biodegrade, and hydrolyze in soils and surface waters. Once 1,2-dichloropropane and 1,2,3-TCP have entered the groundwater, further breakdown products

Formatted: Font: Italic

Formatted: Font: Italic

are unlikely to be generated, because both compounds are resistant to hydrolysis and biodegradation.

1,2,3-TCP is not readily biodegraded and is only slowly transformed by bacteria under aerobic and anaerobic conditions. And, 1,2,3-TCP has not been shown to bioaccumulate.

## Uses and Manufacturers

---

### Uses

1,2,3-TCP ~~was has been~~ used as a solvent for hydrophobic compounds and resins, as a paint and varnish remover, and ~~as~~ a degreasing agent up to approximately the 1950's ~~or and~~ ~~perhaps the~~ 1960's. Another documented use was the application of 1,2,3-TCP ~~was~~ as a "branching agent" in polysulfide polymers, which were used as sealants for aircraft fuel tanks and as a binder for rocket fuel (Kirk Othmer Encyclopedia of Chemical Technology, 2004). 1,2,3-TCP has also been used in a mixture with 1,3-dichloropropene and 1,2-dichloropropane as soil fumigants to control nematodes affecting agriculture. 1,2,3-TCP is currently used primarily as a chemical intermediate in the production of polysulfone liquid polymers and dichloropropene, synthesis of hexafluoropropylene, and as a cross-linking agent in the synthesis of polysulfides. It is also produced in significant quantities as a by-product ~~during of~~ the production of other chlorinated compounds, including epichlorohydrin.

### Solvent

1,2,3-TCP had been used in the past primarily as a solvent for paint and varnish removal, as a cleaning and degreasing agent, and as a cleaning and maintenance solvent. No current information is available to indicate that it continues to be used for these purposes (National Toxicity Program, 2005).

### Soil Fumigants

Pre-1980's, agricultural use of chloropropane-containing soil fumigants for use as pesticides and nematicides was prevalent in the U.S. Some soil fumigants, which contained a mixture of primarily 1,3-dichloropropene and 1,2-dichloropropane, and in which 1,2,3-TCP was a minor component (e.g., trade name of D-D), were marketed for the cultivation of ~~a~~ variousety of crops including: citrus fruits, pineapple, soy beans, cotton, tomatoes, and potatoes. D-D was first marketed in 1943, but is no longer available in the U.S., and has been replaced with Telone II, which was first available in 1956. Telone II reportedly contains as much as 99 percent 1,3-dichloropropane and up to 0.17 percent by weight ~~of~~ 1,2,3-TCP (Zearth, et al. 1998). Before 1978, approximately 55 million pounds/year of 1,3-dichloropropene were produced annually in the U.S., and approximately 20 million pounds/year of 1,2-dichloropropane and 1,2,3-TCP were produced as by-products in the production of 1,3-dichloropropene. Over two million pounds of pesticides containing 1,3-dichloropropene were used in California alone in 1978. Telone II is still used for vegetables, field crops, fruit and nut trees, grapes, nursery crops and cotton.

## Aircraft Fuel Tank Sealers

Another documented use of 1,2,3-TCP was as a “branching” or curing agent in polysulfide polymers (Kirk Othmer Chemical Encyclopedia, 2001). Polysulfide polymers have been used as the “standard sealant for virtually all aircraft fuel tanks and bodies” since the 1950s. Also, “one of the first large-scale applications of the liquid polysulfides was as a binder for rocket fuel,” from 1946 until 1958. [Summary tables published by Kirk Othmer-s \(2001\) tables](#) list [the](#) properties of a number of Morton Thiokol LP series of polysulfide polymer-based sealers, with concentrations of the branching agent (1,2,3-TCP) ranging from 0.5 to 2.0 percent. Liquid polysulfide polymers are used mainly as sealants [in manufacturing applications](#), including [applications related to](#) double paned windows, boat hulls and decks, printing rolls, integral aircraft fuel tanks, and aircraft bodies.

## Chemical Intermediates

By the early 1980s, approximately 95% of chloropropanes were being used as chemical intermediates. Chemical intermediates are industrial chemicals that are used as the starting point to produce other chemicals. 1,2,3-TCP is currently used as an intermediate in the production of polysulfone liquid polymers, the synthesis of hexafluoropropylene, and as a cross-linking agent in the synthesis of polysulfides.

Polysulfone liquid polymers are used in the following industries: aerospace, automotive, consumer goods, electrical and electronic, health care, and in industrial equipment, such as compressor and pump valve components. Hexafluoropropylene is a fluorointermediate that is a key building block required to produce Teflon fluoropolymers and has applications in the agrochemical, electronics, dyes/pigments, pharmaceutical, and specialty polymer markets. Polysulfides are used as catalyst sulfidation agents and in the formulation of lubricant additives for [extreme pressure functionality. \(What does this mean?\)](#)

Formatted: Font color: Orange

## Manufacturers

1,2,3-TCP is manufactured as a stand-alone product in the U.S. It is also produced in significant quantities as an unwanted byproduct of the production of other chlorinated compounds such as epichlorohydrin, and is used internally by manufacturers as an intermediate in the production of other chemicals such as polysulfone and epoxy resins (see Table B-1 below).

**TABLE B-1**  
1,2,3-TCP Manufacturing Information

Item	Description	Comments
Current U.S. Manufacturers	Dow Chemical Company, Freeport, Texas Shell Chemical Company, Deer Park, Texas	Primary source of 1,2,3-TCP in the U.S. and potential supplier for facilities or businesses in Area 3.
Bulk Uses/Origins	External sale Unwanted byproduct of the production of other chlorinated compounds, including dichloropropene, propylene chlorohydrin, dichlorohydrin, glycerol, and especially epichlorohydrin	The majority (>80%) of the 1,2,3-TCP produced in the U.S. is a byproduct of epichlorohydrin production and is incinerated onsite (WHO, 2003). There are 20 to 30 epichlorohydrin facilities in

**TABLE B-1**  
1,2,3-TCP Manufacturing Information

Item	Description	Comments
Production	<p>Chemical intermediate</p> <p>U.S. annual production of 1,2,3-TCP in 2000 estimated to be 9,000 to 14,000 tons.</p> <p>50,000 tons of 1,2,3-TCP is produced globally as a byproduct of other chlorinated compounds (WHO, 2003).</p>	<p>North America, Europe, and Asia.</p>
History	<p>Production of chloropropanes (e.g., 1,2,3-TCP, 1,2-dichloropropane, etc.) for external sale starting to be curtailed by the early 1980's.</p> <p>Chloropropanes were no longer sold for consumer use (as solvents) and, production of 1,2-dichloropropane (and 1,2,3-TCP) for agricultural use by DOW Chemical Co. was discontinued by 1983.</p>	

## Regulatory Levels

A summary of regulatory levels for 1,2,3-TCP is provided below, followed by more detailed text descriptions.

**Table C-1. Regulatory and Water Quality Levels**

Regulatory Level	Agency	Concentration
Federal MCL	USEPA, Region 9	NA
California MCL	DHS	NA
California Notification Level	DHS	0.005 ug/L
Detection Limit for Purposes of Reporting (DLR)	DHS	0.005 ug/L
<b>Preliminary Remediation Goals (PRGs)</b>		
PRG - tap water (10 <sup>-6</sup> cancer risk)	USEPA, Region 9	0.0056 ug/L
PRG - tap water (noncancer risk)		30 ug/L
PRG - residential soil (10 <sup>-6</sup> cancer risk)		0.034 mg/kg
PRG - residential soil (noncancer risk)		71 mg/kg
PRG - industrial soil (10 <sup>-6</sup> cancer risk)		0.076 mg/kg
PRG - industrial soil (noncancer risk)		270 mg/kg
USEPA Risk Information (IRIS) Reference Dose as a Drinking Water Level	USEPA	42 ug/L
Drinking Water Health Advisory or Suggested No-Adverse Response Level (SNARL) for toxicity other than cancer risk	USEPA	40 ug/L
Notes: NA - not applicable (standard does not exist)		

## California Notification Level

In May 1999, the California Department of Health Services (DHS) Division of Drinking Water and Office of Health Hazard Assessment announced an action level (now referred to as a notification level [NL]) of 0.005 µg/L for 1,2,3-TCP. The NL is based on the categorization of 1,2,3-TCP as a probable human carcinogen, on the discovery of 1,2,3-TCP in groundwater at the San Fernando Valley Superfund Site (Area 1 - North Hollywood and Burbank), California, and over a concern that the chemical might find its way into public drinking water supplies.

### UCMR Monitoring

In 2001, to obtain information about the presence of 1,2,3-TCP in drinking water sources, DHS adopted a regulation that included 1,2,3-TCP as an unregulated contaminant for which monitoring is required (UCMR). For this monitoring, DHS developed protocols for analytical methods for 1,2,3-TCP at levels comparable to the NL of 0.005 µg/L. Monitoring under the UCMR regulation was to have been completed by the end of 2003.

~~The adoption of these regulations were adopted~~ occurred before the availability of ~~a~~ analytical methods capable of achieving ~~the~~ 1,2,3-TCP's detection limit reporting (DLR) of 0.005 µg/L ~~for 1,2,3-TCP~~. Some utilities proceeded with monitoring, using ~~insufficiently sensitive~~ laboratory analyses with higher DLRs. Unfortunately, ~~findings of non-detects (ND) reported using a method~~ with a DLR higher than 0.005 µg/L ~~do not~~ provide DHS with ~~inadequate information needed for possible to set standards setting~~. DHS's Sanitation and Radiation Laboratory developed an adequate analytical method and some commercial laboratories are able to achieve the 0.005-µg/L DLR with either EPA method 504.1 or 551.1. Therefore, any utility ~~reporting NDs for with 1,2,3-TCP using a method findings of ND~~ with reporting levels of 0.010 µg/L or higher should perform ~~confirmation testing follow up sampling of representative sources for analysis~~ using a method with a 0.005-µg/L DLR.

### Notification of Exceedance of NL

A new law, effective January 1, 2005, requires that public water systems notify local governing bodies (*e.g., i.e.*, city councils and county boards of supervisors) when NLs or MCLs for contaminants in drinking water supplies are exceeded. Even if notification occurred prior to that date under previous and different requirements, water systems ~~managers/custodians/overseers are encouraged to should~~ familiarize themselves with the new ~~notification requirements for information to be provided in such a notice and ensure that they are meeting these requirements and determine whether a new notice should be provided to the governing bodies.~~

## EPA Region 9 PRGs

EPA Region 9 publishes Preliminary Remediation Goals (PRGs) for guidance in performing site remediation, feasibility studies, and risk assessments. PRGs for 1,2,3-TCP are provided with cancer and non-cancer assumptions in Table C-1 (EPA Region 9, October 2004).

## APPENDIX D

# Occurrences of 1,2,3-TCP Environmental Contamination in the U.S.

---

1,2,3-TCP may have been released to the environment as a result of its manufacture, formulation, and use as a solvent and extractive agent, paint and varnish remover, cleaning and degreasing agent, cleaning and maintenance agent, and chemical intermediate. Releases may occur as a result of disposal of products that contain the chemical or through agricultural land use applications of certain soil fumigants that are known to contain 1,2-dichloropropane and 1,2,3-TCP. In these instances, the fumigant was injected into the root zone, after which the soil was compacted to enhance retention of the vapor. Releases may have also occurred through the disposal of 1,2,3-TCP-containing sewage sludge from municipal sewage treatment plants.

1,2,3-TCP groundwater contamination has been detected at sites where the manufacture or use of 1,2,3-TCP containing chemicals occurred and at locations that used 1,2-dichloropropane as a soil fumigant (in which 1,2,3-TCP was an impurity). Information on the occurrence of 1,2,3-TCP at these sites may be of use in identifying and investigating potential sources in SGV Area 3 and is presented below.

## Application of Soil Fumigants

Contamination of groundwater by 1,2,3-TCP as a result of soil fumigants has been observed in California, Hawaii, and British Columbia.

### Central Valley, California

1,2,3-TCP groundwater contamination associated with the use of 1,2-dichloropropane as a soil fumigant was observed in the Central Valley of California (City of Shafter, 2000). In 1999, 1,2,3-TCP was detected in five of six active water supply wells at concentrations ranging from 0.02 to 0.11 µg/L (Howe, 1999). 1,2,3-TCP was found in groundwater from all wells where 1,2-dichloropropane was detected. Although 1,3-dichloropropene had been applied heavily (thousands of pounds per section), little to none showed up in groundwater from the Merced and Visalia DHS Districts. This was postulated to be due to fact that 1,3-dichloropropene, an unsaturated ~~alkane~~ alkene, would be more easily biodegraded than 1,2-dichloropropane and 1,2,3-TCP, both of which are saturated hydrocarbons. In summary the presence of 1,2,3-TCP was positively correlated with 1,2-dichloropropane, but not with 1,3-dichloropropene.

The California Department of Pesticide Regulation advised that 1,2,2-TCP should also be analyzed where 1,2-dichloropropane and 1,2,3-TCP were detected in groundwater, as it is a byproduct of the manufacture of 1,3-dichloropropene.

## Occurrence at Industrial Sites

### San Gabriel Valley Superfund Sites, California

Specific sources of 1,2,3-TCP contamination in groundwater in the SGV have not been identified. However, based on results in EPA's San Gabriel Basin database, 1,2,3-TCP concentrations in groundwater at the Wynn Oil facility in the Baldwin Park OU have been as high as 46,000 ng/L and 1,2,3-TCP has been detected in groundwater downgradient of the Wynn Oil facility at [a concentration of](#) 10,000 ng/L (beneath the Aerojet Electrosystems facility). 1,2,3-TCP was also detected in groundwater at the Spectrol Electronics facility in the Puente Valley OU at a concentration of 54,000 ng/L. Because groundwater samples at these facilities were analyzed before mid-1995, confirmation sampling using more recent analytical methods (see Section 5) may be warranted. 1,2,3-TCP has also been detected in groundwater downgradient of the TRW Benchmark facility in the Puente Valley OU at [concentrations](#) up to 44 ng/L (in October 2003).

### San Fernando Valley Superfund Site (Area 1 – North Hollywood and Burbank Operable Unit Superfund Site, California

The use of 1,2,3-TCP for aircraft fuel tank sealers is suspected to be one of the sources of 1,2,3-TCP groundwater contamination in the Burbank OU at the San Fernando Valley Superfund Site (Area 1 - North Hollywood and Burbank), California. 1,2,3-TCP was detected in groundwater from 9 of the 39 monitoring wells in the Burbank OU, with concentrations ranging from 0.19 µg/L to 170 µg/L (Tetra Tech, 2003). The highest concentrations of 1,2,3-TCP occurred in samples collected from near the groundwater table. An area of 1,2,3-TCP groundwater contamination exceeding 0.1 µg/L, appearing to originate near the Burbank-Glendale-Pasadena Airport and extends approximately 5,000 [feet?](#) downgradient, was generally defined. Lockheed Martin Corporation maintained operations [at](#) numerous locations adjacent to the airport and had at least two tanks (3,000 and 12,000 gallons) containing aircraft fuel tank sealant at a facility (Plant B-5) south of the airport. At Lockheed Martin's B-6 plant, east of the airport, a small portion of the subsurface soil samples were analyzed for 1,2,3-TCP, and only one sample contained detectable 1,2,3-TCP (1,500 µg/kg at a depth of 50 feet bgs). The sample was collected close to a building previously used for testing of aircraft fuel system components at the B-6 plant.

Tetra Tech (2003) identified the Crane Company - Hydro-Aire Division, where aviation, aeronautical, and missile control systems were manufactured, as another potential source of 1,2,3-TCP in groundwater, presumably on the basis of 200 µg/L of 1,2,3-TCP being measured in a monitoring well at the facility. A soil gas survey was completed during 2003 at the Aeroquip Corporation facility, where assembly and distribution of industrial hoses occurred, in the Burbank OU (Tetra Tech, 2003). Groundwater from the Crane Company - Hydro-Aire Division monitoring well downgradient of this facility contained 200 µg/L 1,2,3-TCP, so the Aeroquip Corporation facility was thought to be a potential source of 1,2,3-TCP observed in groundwater. Fifty-four soil gas samples were analyzed for 1,2,3-TCP, however [1,2,3-TCP](#) was essentially not detected in any soil gas samples above the detection limit of 1 µg/L. A trace concentration close to the method detection limit of 0.2 µg/L was observed in only one sample (Pavlick, 2005). Both the Crane Company - Hydro-Aire

Division and Aeroquip Corporation facilities are located downgradient of Lockheed Martin's B-6 plant.

### **MacKenzie Chemical Works, New York**

At the former MacKenzie Chemical Works Site in Central Islip, Suffolk County, New York, concentrations of 1,2,3-TCP up to 3,900 µg/L in lagoon water and up to 8,900 µg/L in offsite groundwater (600 feet downgradient) were observed, along with lower concentrations of TCE, PCE, and benzene, toluene, ethylbenzene, and xylene (BTEX) compounds (ATSDR, 2004). MacKenzie used the property from 1948 to 1987 for the manufacture of various chemical products, including fuel additives and metal acetylacetonates. MacKenzie stored 1,2,3-TCP in three 10,000-gallon tanks on the property. Other historical waste sources include aboveground storage tanks, leaking drums, waste lagoons, cesspools, and storm water drywells. The lagoons, cesspools, and drywells were sampled and found to contain contaminants attributable to facility operations, including 1,2,3-TCP at concentrations up to 20,400 µg/kg. Soil vapor concentrations of 1,2,3-TCP up to 60-2,200 µg/m<sup>3</sup> were detected onsite. EPA's selected a remedy for the site called for thermally-enhanced in situ soil vapor extraction (SVE) for soils contaminated with VOCs, limited excavation and offsite disposal for soils contaminated with semi-volatile organic compounds, demolition of a former laboratory building, and treatment of the groundwater using in situ air sparging with ozone injection.

### **Marine Corps Air Station (MCAS) Tustin, California**

This former Marine Corps Air Station (MCAS) in Orange County, California was closed under Base Realignment and Closure (BRAC) and remaining contamination is being remediated prior to base reuse. The proposed plan for OU-1A (the area of TCE and 1,2,3-TCP groundwater contamination at the former MCAS Tustin) describes hydraulic containment with soil hot spot removal as the final remedy. The Department of the Navy is currently treating MTBE, the primary contaminant in groundwater, and 1,2,3-TCP, using in situ chemical oxidation. Pumped groundwater is being treated using the HiPOx treatment system. Both MTBE and 1,2,3-TCP are destroyed using ozone and hydrogen peroxide to create highly reactive hydroxyl radicals, which oxidize organic chemicals (See Section 6 for a discussion of the ongoing remediation). 1,2,3-TCP groundwater contamination at the former MCAS Tustin is associated with a former vehicle maintenance building, and degreasing or cleaning solvents used there may have contained 1,2,3-TCP (Werkmeister, 2005).

### **Tyson's Dump, Pennsylvania**

The Tyson's Dump site, located in Montgomery County, Pennsylvania, is a four-acre abandoned sandstone quarry that was used to dispose of septic and chemical waste from 1962 to 1970. Waste disposal occurred in a series of unlined lagoons. In the 1970s, sludges and liquid wastes, primarily chlorinated and other organic solvents, were dumped into the lagoons (USEPA, May 2004).

Full-scale remediation of soils, bedrock, and groundwater is underway at the Tyson's Dump site. The cleanup involves in situ vacuum extraction in the silty clay soils of the former lagoons and surrounding area, which contains upwards of 250,000 mg/kg total VOCs and

semivolatiles. The major contaminants of concern are 1,2,3-TCP, toluene, xylenes and dichlorobenzene, although there are also approximately 20 other compounds identified (See Section 6 for a discussion of the ongoing remediation).

### Ciba-Geigy Superfund Site, New Jersey

Historic operations at the Ciba-Geigy Superfund Site in Toms River, New Jersey previously included the manufacture of dyes, pigments, resins, and epoxy additives. Sludges and process wastes were stored at a few locations around the former operations, resulting in groundwater contamination by many VOCs, including 1,2,3-TCP. Mean concentrations of the “north plume” at the site were 47 µg/L. The groundwater ROD prescribed a slurry wall, groundwater plume capture wells, a groundwater treatment plant, treated groundwater injection wells, a slurry wall, drum removal, and removal of contaminated soil (USEPA, September 29, 2000). The selected remedial alternative for the source areas at the site is on-site ex-situ bioremediation with off-site treatment/disposal of drummed material (USEPA, June 15, 2000).

The Ciba-Geigy site-specific pilot study performed from October 1999 to April 2000, revealed that ex-situ biological treatment reduced Chemicals of Concern (COCs) concentrations by greater than 90% and reduced the leaching of COCs by more than 99 percent. However, some COCs, such as PCE and 1,2,3-TCP, did not respond to the aerobic biodegradation process.

### RCRA Reported Releases

Known reported releases of 1,2,3-TCP into the environment during 2002 are summarized below (Scorecard website, 2005). Note that the great majority of these releases are to air. The only documented release to water was by Dow Chemical Company (4,225 pounds; not shown in Table D-1).

**TABLE D-1**  
Reported RCRA Releases in the United States During 2002

Rank	Facility	Total Release in 2002 (Pounds)
1.	Deer Park Refining L.P., Deer Park, TX	84,859
2.	Dow Chemical Co., Freeport Facility, Freeport, TX	6,520
3.	Resolution Performance Products, Deer Park Plant, Deer Park, TX	5,330
4.	Resolution Performance Products L.L.C., Norco, LA	1,129
5.	Oxy Vinyls L.P. Deer Park, VCM Plant, Deer Park, TX	108
6.	Dow Chemical Co., Louisiana Div., Plaquemine, LA	57

## Health Risk Information

---

Human exposure to 1,2,3-TCP can occur from inhalation, ingestion of contaminated water, dermal contact with contaminated soil or water, and working in a facility where 1,2,3-TCP is used. 1,2,3-TCP can be measured in blood, urine, and breath. However, it breaks down quickly and leaves the body in breath, urine, and feces.

1,2,3-TCP causes cancer in laboratory animals (US EPA, 1997), which is the basis for the California DHS NL. It is reasonably anticipated to be a human carcinogen (NTP, 2005). In 1999, 1,2,3-TCP was added to the list of chemicals known to the state of California to cause cancer [Title 22, California Code of Regulations, Section 12000].

### Health Effects

The main adverse health effect from exposure to 1,2,3-TCP in both animals and people is damage to the respiratory system. Exposure to high levels (100 ppm) of 1,2,3-TCP for a short time can cause central nervous system damage, liver damage and eye, skin and throat irritation. Rats and mice died after breathing air containing 1,2,3-TCP. After When swallowing ed 1,2,3-TCP at high levels, rats died from liver and kidney damage. At moderate non-lethal doses, rats had minor liver and kidney damage, blood disorders and stomach irritation. Animals that swallowed low doses for most of their lives developed tumors in several organs. When applied to the skin of rabbits, 1,2,3-TCP caused severe irritation, followed by injury to internal organs.

In the Eighth Report on Carcinogens (1998), 1,2,3-TCP is listed, for the first time, as a substance reasonably anticipated to be a human carcinogen. It is also listed in the Toxic Release Inventory (TRI) as an Occupational Health and Safety Administration (OSHA) carcinogen. However, the Department of Health and Human Services, USEPA, and the International Agency for Research on Cancer have not classified 1,2,3-TCP for carcinogenicity.